UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project   Date   Author

TITLE

EXPERIMENTS WITH PENETRATING SPRAYS CONDUCTED IN LODGEPOLE AND WHITEBARK PINE IN 1940

by
Archie L. Gibson
Assistant Entomologist

Forest Insect Laboratory
Coeur d'Alene, Idaho
June 9, 1941

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SUBJECT—

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Forest Insect Laboratory
Coeur d'Alene, Idaho

January 26, 1942

To: F. P. Keen, in Charge, Portland Laboratory

From: James C. Evenden, in Charge, Coeur d'Alene Laboratory

Subject: Mortality Estimates from Brood Counts Associated with the Use of Penetrating Sprays

I wish to thank both you and Mr. Furniss for your letter of January 13.

It seems that after all our discussion and argument we are back to approximately the same place as where we started, with the one exception that we are all very much in accord that the method of determining brood mortality as a result of these sprays used by Mr. Gibson is subject to some question. Different individuals seem to question different phases of this procedure; yet I am sure that regardless of the entomological factor of normal brood mortality, which is obviously a factor, we all admit that unless ample data are obtained to permit a thorough statistical analyses of the data, the use of such figures as 97.6%, 98.2%, or 99.7% are of little value in an actual comparison of the different treatments employed. In brief, unless it is feasible to obtain these accurate data, we come back to the position of a satisfactory or unsatisfactory treatment.

I appreciate your comments upon this interesting subject and wish we could have some time together for a more thorough discussion of the different factors involved.

James C. Evenden
S.E.

DICTATED BY MR. EVENDEN BUT SIGNED
IN HIS ABSENCE TO AVOID DELAY.

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Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
January 13, 1942

To: J. C. Evenden, in Charge, Coeur d'Alene Laboratory

From: F. P. Keen, in Charge, Portland Laboratory

Subject: Mortality Estimates from Brood Counts

I have read the exchange of correspondence between Furniss, Gibson, and you on mortality counts in connection with penetrating sprays, but saw no reason to put in my oar and thus add to the babel of tongues.

This matter of sampling for mortality can be quite complex if one tries to get in all the fine points, but for your purpose in testing the effectiveness of sprays I see no reason to do this. As Dr. Craighead points out, what you are most interested in is the gross result of whether the spray was satisfactory or unsatisfactory and this can be determined by simple observations without making any bark counts at all.

If, however, you wish to compare two sprays of nearly equal effectiveness, then a large amount of brood counting needs to be done. The more nearly equal the effectiveness, the more data it will take to demonstrate any significant differences.

For such a purpose, I agree with Furniss that you could use your time to the best advantage in comparing the end results; i.e., counting a large number of samples from treated trees and a similar number of untreated trees after treatment was complete. What has happened before in the way of normal mortality is of little importance. All you need to know is that at time of treatment the treated trees were typical of the general brood trees and had brood in them. The number of samples which you will need to count from treated and untreated trees will depend upon the standard deviations of brood counts which you find. If the dispersion ~~around~~ the average is large it will take more samples than if they all fall together (around 100 percent kill, for instance). You are probably familiar with the

technique of comparing two sets of data for the purpose of testing significance of differences. The technique is simple enough, but sometimes the counts have to be excessively large if you are attempting to show minor differences between treatment and check.

I don't believe I have other comments to make as the details of this problem have been pretty thoroughly thrashed out in the voluminous exchange of correspondence which has already developed on this subject.

FPKeen:RWO

cc: Dr. Craighead

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Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
January 13, 1942

To: Archie L. Gibson, Box 630, Coeur d'Alene, Idaho
(Through F. P. Keen and J. C. Evenden)

From: R. L. Furniss, Associate Entomologist

Subject: Penetrating Sprays (Mortality Estimates)

Judging from your letter of December 18 and Mr. Evenden's of August 10, I am sure that we three could have a very interesting discussion of insect population sampling, especially the phase relating to estimating bark beetle mortality. I have discussed the subject with several of the men here and more recently with Dr. F. M. Wadley. As a consequence I am prompted to volunteer the following comments.

So far as the method employed in your report is concerned; that is, sampling at the time of treatment and again later when mortality has occurred, I remain unconvinced that normal mortality should be ignored--at least if a true measure of effectiveness of treatment is desired. It is true, as Evenden points out, that normal mortality may be so slight during the test period as to be negligible. It is also true that when normal mortality is a constant it sometimes need not be eliminated in a comparison of several methods of treatment. This would be the case in parallel treatments, such as yours, but not in comparisons of tests made under different conditions. Where the introduction of a normal mortality figure in calculating effectiveness of treatment is a disrupting influence, as in the two cases you point out, this merely means that the sampling is somehow at fault and does not detract from the fact that normal mortality is not part of the effect of treatment.

Thus we come to the matter of sampling, which is actually what motivated the original comment, although I did not state so at the time. Personally I am not sure that the before and after sampling is profitable, except as an extreme refinement when all other factors, including the accuracy of sampling, have been taken into account. It seems to me that equal accuracy with much less effort can be attained in comparing emergence from treated and untreated trees, provided that adequate samples of both the treated and untreated trees are taken. I recognize that a number of biological factors are involved and that considerable work would have to be done in order to determine what constitutes an adequate sample, but the same holds true of both methods. In either case the adequacy of sampling determines the significance of the computed mortalities. Without actual proof, I would say that most of our mortality figures in the past have not been statistically sound. Keen's analysis of brood counts of D. brevicomis serves to bear out this contention. This being the case, the broad general rating mentioned by Evenden may be the only practical measure of mortality. If so, we should all proceed on that basis and not attempt further refinement of data. I feel, however, that much can still be accomplished by detailed sampling and hope that you can find time to analyze your D. monticolae brood data with the idea of determining what can and what can not be done in the way of population estimates.

In closing I would like to say that this discussion is directed at our bark beetle sampling methods generally. Your report merely served to touch it off.

RLFurniss:RWO

cc: Dr. Craighead

File No.
Noted by RLF

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

December 18, 1941

To: F. P. Keen, 445 U. S. Court House, Portland, Oregon

From: James C. Evenden, Box 630, Coeur d'Alene, Idaho

Subject: Penetrating Sprays

I am submitting Mr. Gibson's comments which he has made in answer to Mr. Furniss' letter of July 30, 1941.

I should also like to call your attention to Dr. Craighead's letter to me of October 27, in which he comments upon the exchange of correspondence between this laboratory and your station concerning mortality statistics. You will note in Dr. Craighead's letter that he remarks that he is sending a copy of his letter to you and expects you to come back with a very learned rebuttal. Seriously, I wish you could find time to let us have your reaction to this question of determining the mortality obtained from penetrating sprays and the consideration which we should give to the normal mortality. I am very much interested in this subject, and although I feel rather confident of my position, I recognize that I do not have a very sound statistical foundation for it.

James C. Evenden

Enclosure

cc to Dr. Craighead

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

December 18, 1941

To: R. L. Furniss, 445 U. S. Court House, Portland, Oregon (Through F. P. Keen)

From: Archie L. Gibson, Box 630, Coeur d'Alene, Idaho

Subject: Penetrating Sprays

The question of evaluating control when normal mortality is high has been something of a puzzle to me. The contention can be made that when treatment is applied at a certain time all subsequent mortality should be credited to the treatment. However, we do know that a certain amount of normal mortality would have occurred even if control had not been instituted, so many workers credit treatment only with the amount of mortality represented by the difference between normal mortality and that secured from the treatment. I feel that the latter procedure should be followed where normal brood reduction is high between times of treatment and examination, but that it could be ignored for all practical purposes where the reductions are slight. Another factor that I feel should be considered in evaluating control is the final number of survivors. For instance, brood in one case may have been 100 per square foot when treated, decreasing to 10 per square foot at emergence. The reduction, no normal mortality considered, is 90 percent, but the survival is too high per unit of area to be considered satisfactory. In a second case, brood may have declined during the same period from 40 to 4 per square foot, which, on the same basis as above, may be considered acceptable, as the survivors, in the case of the mountain pine beetle, would be less than 25% of the number attacking.

I did not consider normal mortality in working up my data because, frankly, I felt it was too high for the period involved. Since receiving your comments I've been endeavoring to derive a normal mortality curve for the mountain pine beetle in lodgepole pine. Due to the decided variability in number of brood per unit of areain that host, a large quantity of data is necessary to give a dependable figure for all stages of development and the derived figure is only good for that year. We haven't what I consider to be enough data on mortality occurring between the callow adult stage and completion of emergence. Bedard showed only about 45 percent decrease for the same insect in western white pine from the callow adult stage until emergence. However, let's see what are the results when we consider 64 percent as the normal mortality and credit sprays with the difference between that estimated reduction and what was actually noted.

Tests in Lodgepole Pine

Table No.	Formula		Normal mortality	Total mortality	Estimated survival per sq.ft. if untreated	Mortality due to treatment	Survival per sq.ft.in treated material	Conclusion as to control
1	(1) Sat. sol. naph. in orthene Diesel oil	1 part 6 parts	64	99	7.0	98	.17	Excellent
2	(1) Sat. sol. naph. in orthene Diesel oil	1 part 9 parts	64	92	4.2	65	1.6	Acceptable
3	(2) Same as 2 except Santomerse D 1% by weight added		64	97	6.4	92.5	.5	Good
4	(3) Pentachlorphenol Diesel oil	2% 98%	64	57	12.6	Favored survival?	15.1	Worse than no treatment?
5	(3) Pentachlorphenol Diesel oil	3% 97%	64	26	10.8	"	22.2	"
6	(3) Pentachlorphenol Diesel oil	4% 96%	64	78	18.7	39	11.4	Unsatisfactory
7	(3) Pentachlorphenol Diesel oil	6% 94%	64	73	10.8	24	8.2	"
8	(1) Dichlorethyl ether Diesel oil	1 part 8 parts	64	99	14.3	99	.15	Excellent
9	(3) Orthonitrodiphenol Diesel oil	1 part 3 parts	64	96	11.6	89	1.3	Acceptable
10	(1) Sat. sol. naph. in xylene Diesel oil	1 part 5 parts	64	95	5.1	86	1.7	Acceptable

(1) By volume (2) By weight for Santomerse D (3) By weight

From the preceding data it may be seen that six of the ten spray mixtures listed gave control varying from "acceptable" to "excellent", based on both the amount of reduction and the survival. The conclusions in the above tabulation have no material variation from those in the report when the other factors, mentioned in the text, are considered.

On the basis of a 64 percent normal mortality, sprays used in experiments 4 and 5 favored survival rather than reduction of brood. The only conditions under which I can visualize that happening would have been that the spray repelled or killed parasitic and predacious insects but was not lethal to mountain pine beetle brood. That this was not the case is revealed by the examinations which followed treatment, showing living predators and by the fact that the trees were sprayed when the infesting brood was almost completely in the pupal and new adult stages. Coeloides could have caused little reduction here because it works only on the large larval stages. Therefore I can not help but feel that the 64 percent figure is too high. In my estimation it should be nearer 45 percent. I have prepared a table similar to the preceding one, but using 45 percent as the normal mortality:

Tests in Lodgepole Pine

Table No.	Normal mortality	Total mortality	Estimated survival per sq.ft. if untreated	Mortality due to treatment	Survival per sq. ft.	Conclusion
1	45	99	21.7	99	.77	Excellent
2	45	92	11.5	86	1.6	Acceptable
3	45	97	9.8	95	.5	Good
4	45	57	19.3	22	15.1	Unsatisfactory
5	45	26	16.6	Favored survival?	22.2	"
6	45	78	28.6	60	11.4	"
7	45	73	16.4	50	8.2	"
8	45	99	22.9	99	.15	Excellent
9	45	96	17.8	93	1.3	Acceptable
10	45	95	8.4	91	1.7	"

From the preceding table it is seen that "percent of mortality due to treatment" is placed in a much more favorable light, but the final conclusions are not materially changed, either from those in the preceding table or in the text of the report.

I hope this long dissertation clarifies my position rather than makes it more confused. It is gratifying to have someone take as much trouble as you have to comment on the report and I wish to express my appreciation and invite further suggestions.

Copy of this letter is being sent to Dr. Craighead.

Archie S. Gibson

File No.
Noted by

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
WASHINGTON, D. C.

October 27, 1941

To: J. C. Evenden, P. O. Box 630, Coeur d'Alene, Idaho

From: F. C. Craighead, in Charge, Forest Insect Investigations

Subject: Penetrating Sprays

We are pleased to have your letter of October 18 telling of the progress you are making with the fall experimental work with penetrating sprays.

I was surprised at the effect of one of the wetting agents in producing a solid spray. It is possible that there may be some other newer wetting agents on the market now and a letter to Whitten or Collins who seem to keep up on this matter, might bring further information. We may have some difficulty in obtaining ortho during the next year.

I was much interested in the exchange of correspondence with Keen about mortality statistics in expressing the results of spray tests. You will remember we had quite an argument on the Teton several years back with Gibson and I certainly lean toward your view that a broad general rating is the most practical way of expressing these things.

Your terms "satisfactory" and "unsatisfactory" should be ample provided you mean by "satisfactory" almost complete control. Of course, occasionally you might get nearly complete control from natural factors but if the experiments are repeated again, which we nearly always do, such would show up.

Personally I cannot see any value in making detailed studies of mortality and mortality factors in this sort of experimental work. If the results are good enough to use on a control project, that is all that is necessary. Too much refinement in a thing of this kind can lead to such over-emphasis of the statistical end of it that practical results are lost in refinement of technic.

I am sending a copy of this to Keen and no doubt he will come back with a very learned rebuttal. However, with my limited knowledge of statistics, he will have to waste a lot of energy to convince me otherwise.

FCCraighead:ES

F C Craighead

FPK

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Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
October 20, 1941

To: J. C. Evenden

From: R. L. Furniss (Through F. P. Keen)

Subject: Penetrating Sprays

Enclosed is a copy of my letter of July 30 commenting on Gibson's report "Experiments with Penetrating Sprays Conducted in Lodgepole and Whitebark Pine in 1940". His mortality estimates are discussed in this letter. We were unable to locate any reply.

Enclosure

RLFurniss:RWO

File No.
Noted by RLF.

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

October 18, 1941

To: F. P. Keen, 445 U. S. Court House, Portland, Oregon

From: James C. Evenden, Box 630, Coeur d'Alene, Idaho

Subject: Penetrating Sprays

A mystery exists at the Coeur d'Alene Laboratory. In July or early August Mr. Furniss wrote a letter commenting upon Mr. Gibson's method of arriving at a percentage of mortality without considering normal brood mortality. I answered this letter, asking Gibson to write an additional memorandum concerning the percentage of mortality secured. My answer was to be held here until Mr. Gibson's memorandum was received. The mystery which exists is that we can not find Mr. Furniss' letter or my reply. It is still possible that Mr. Gibson may have it, although he states that he does not. This mystery developed a week or so ago when I decided that I would not wait any longer for Mr. Gibson's memorandum but would forward my answer to the percentage-of-mortality questions Mr. Furniss had asked. In order that we may properly answer Mr. Furniss' letter I am wondering if it would be asking too much if you would have a copy made from your carbon and send it to us.

James C. Evenden

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

August 10, 1941

To: F. P. Keen, 445 U. S. Court House, Portland, Oregon

From: James C. Evenden, Box 630, Coeur d'Alene, Idaho

Subject: Experiments with penetrating sprays conducted in lodgepole pine and whitebark pine in 1940 by Archie L. Gibson

Attention: Mr. R. L. Furniss

Thank you for your comments concerning Mr. Gibson's report "Experiments with Penetrating Sprays Conducted in Lodgepole and Whitebark Pine in 1940", and the questions that you have asked. I hope that I can present my side of the normal brood mortality question as convincingly as you have done with the analyses of our figures.

In using naphthalene flakes with orthodichlorobenzene we have had some difficulty with recrystallization when lower temperatures were encountered. In fact, when heat is used to place the naphthalene in solution with oil, crystallization will occur as the mixture cools. Orthodichlorobenzene is a rather good solvent, and one gallon of orthodichlorobenzene will dissolve and hold approximately 3 pounds of naphthalene flakes under ordinary air temperatures. Then when this is added to the 4 gallons of oil we have had no difficulty in holding this substance in solution. We have conducted some additional experiments this year as to the advantage of a saturated solution of "Ortho" and naphthalene flakes, with fuel oil, but I do not believe our results will show any significant advantages over the Ortho-fuel oil combination.

Your question regarding the percentage-of-mortality figures used in Mr. Gibson's report to depict the results of penetrating sprays is one that has often been discussed at this laboratory, with Mr. Gibson defending the role of normal brood mortality. I am glad that you have raised this question, for I have believed that there is a simpler and less questionable method of showing this effectiveness. We recognize normal brood mortality as a factor that under certain conditions makes the figures used by Mr. Gibson of little significance, while under other circumstances they tell a rather accurate story. May I illustrate my position with a few specific assumed cases:

1st Example

Tree contained at time of treatment a brood of 60 small larvae per square foot of bark surface, with an estimated final emergence of 20. Final examination shows that 50 larvae per square foot were killed by the spray. Results:

83 percent of the brood destroyed by the spray.
50 percent control, as emergence per square foot was reduced from 20 to 10.

I have stated that 83 percent of the brood was destroyed by the spray, for this would be the case, although it is recognized that 66 percent of the larvae would subsequently have died from normal causes.

2nd Example

Tree contained at time of treatment 20 mature larvae per square foot of bark surface, with an estimated final emergence of 20. Final examination shows that 10 of the larvae were killed by the spray. Results:

50 percent of the brood destroyed by the spray.
50 percent control, as emergence reduced from 20 to 10.

3rd Example

Tree contained at time of treatment a brood of 60 small larvae per square foot of bark surface, with an estimated final emergence of 20. Final examination shows that all insects were killed by the spray. Results:

100 percent of the brood destroyed by spray.
100 percent control, as emergence reduced from 20 to 0.

One could give many additional examples of the difference in the percent of brood killed and the degree of control attained due to the factor of normal mortality. However, when trees are treated in the late spring when there is little if any additional normal mortality to be expected, and the percent of mortality is obtained from a comparison of living and dead insects, with no question as to the cause of death, the percentage figure represents not only the percent of the insects destroyed but the percent of control. This would be the case in connection with our examination of the treated trees on the Wasatch in 1940 and on the Coeur d'Alene this spring.

My objection to the use of a percentage of mortality figure, as we have used it, is not so much the complications of normal mortality but the difficulty of obtaining accurate data from which this percentage figure can be drawn. Although acceptable data can be obtained from each individual tree at the time of the examination, the factors of delayed mortality during the long period of emergence make the task of obtaining a true mortality figure extremely difficult. However, because of this fact we are sure that the figures obtained are conservative, as we find additional mortality occurring right up to the time of emergence.

I do not concur with you that normal brood mortality should always be deducted from the number of insects killed, to give a correct figure as to the effectiveness of the spray. In recognizing the complications of normal mortality one can not assume the spray to be sufficiently selective to destroy only those insects that will escape normal mortality. If a large percent of the brood was destroyed in a tree that was treated at a time when normal mortality was not complete, then it would seem that the insects that are to subsequently die from normal processes would have suffered proportionately from the spray. On the other hand, if only a small percent of the brood was destroyed, it is possible that the spray was noneffective and that the entire mortality was normal.

In using the percentage-of-mortality figure, it is apparent that it does not indicate the degree of control which is attained. In view of these many and varied complicating factors, it would seem that an effort should be made to establish a more simple and less questionable measure of effectiveness. I have advocated a satisfactory and unsatisfactory rating. If we assume that satisfactory control will only permit an average of X insects per square foot of bark surface, then the treatment could be measured by X+ or X-, with X as the accepted standard. Normal emergence could be established for each experiment or project, through a few carefully selected trees which could be left untreated for that purpose. It would seem that this method would meet many of the objections of the more complicated procedure, and tell a more accurate and less questionable story.

I have asked Mr. Gibson to submit his comments concerning your questions, so I will hold this letter until his reply is received.

Copy of this memo is being sent to Dr. Craighead.

James C. Evenden

COPY

Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
July 30, 1941

To: J. C. Evenden, In Charge, Forest Insect Laboratory
Coeur d'Alene, Idaho

From: R. L. Furniss, Associate Entomologist, Forest Insect
Laboratory, Portland, Oregon (Through F. P. Keen)

Subject "Experiments with Penetrating Sprays Conducted in
Lodgepole and Whitebark Pine in 1940" by Archie L.
Gibson

Gibson's report "Experiments with Penetrating Sprays Conducted in Lodgepole and Whitebark Pine in 1940" has been thoroughly read with a great deal of interest. I would like to take this opportunity to congratulate him upon the progress he has made in the testing of spray materials for control of the mountain pine beetle.

As a matter of personal interest, I would like to know whether he had any difficulty with the recrystalization of the maphthaline in any of the formulae containing that material, in formula 1 for example. Some years ago I had this trouble which resulted in clogging of the spray nozzle. In that case, however, the naphthalene was dissolved at 100 degrees Fahrenhheit, or somewhat higher, and may have resulted in a supersaturated solution with recrystalization at lower temperatures. Might not this same thing happen with Gibson's formulae when used at temperatures below 50 degrees Fahrenheit, as might quite probably be the case on spring control operations in the high mountains?

It seems to me that there is some question concerning the method that Gibson used to determine brood mortality resulting from application of the various materials. Briefly, the objection is that the mortalities attributed to the chemicals include normal mortality. In table 3 page 8, for example, the average brood in the treated logs is shown as 17.7 per square foot at the time of treatment and as .48 at the time of re-examination. On this basis the effieiency of treatment is calnulated to be 97.3 percent. Yet in table 11 the brood in five untreated logs is given as 48.6 per square foot at the time of treatment and as 17.5 when the logs were re-examined-- a normal reduction of 64.0 percent. If we assume for the sake of argument that 64 percent is a fair measure of normal mortality for the period studied, then we have a basis for correcting the estimated effectiveness in table 3. From the original brood of 17.7 per square foot we would expect to obtain 6.4 at the time of re-examination; however, we find only .48, a reduction of 92.5 percent attributable to the chemical treatment. In some of the other tables the differences are much greater. Calculations using the figures in table 7 give a 24 percent effectiveness rather than the 72.6 percent now shown.

By comparing the emergence from the treated logs, .48 per sq. ft., with the emergence from the checks, 17.5 per sq. ft. one gets an effective control of 97.3%

cc; Dr. Craighead

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Forest Insect Laboratory
445 U. S. Court House
Portland, Oregon
July 30, 1941

To: J. C. Evenden, In Charge, Forest Insect Laboratory
Coeur d'Alene, Idaho

From: R. L. Furniss, Associate Entomologist, Forest Insect
Laboratory, Portland, Oregon (Through F. P. Keen)

Subject: "Experiments with Penetrating Sprays Conducted in
Lodgepole and Whitebark Pine in 1940" by Archie L.
Gibson

Gibson's report "Experiments with Penetrating Sprays Conducted in Lodgepole and Whitebark Pine in 1940" has been thoroughly read with a great deal of interest. I would like to take this opportunity to congratulate him upon the progress he has made in the testing of spray materials for control of the mountain pine beetle.

As a matter of personal interest, I would like to know whether he had any difficulty with the recrystallization of the naphthalene in any of the formulae containing that material, in formula 1 for example. Some years ago I had this trouble which resulted in clogging of the spray nozzle. In that case, however, the naphthalene was dissolved at 100 degrees Fahrenheit, or somewhat higher, and may have resulted in a supersaturated solution with recrystallization at lower temperatures. Might not this same thing happen with Gibson's formulae when used at temperatures below 50 degrees Fahrenheit, as might quite probably be the case on spring control operations in the high mountains?

It seems to me that there is some question concerning the method that Gibson used to determine brood mortality resulting from application of the various materials. Briefly, the objection is that the mortalities attributed to the chemicals include normal mortality.

In table 3 page 8, for example, the average brood in the treated logs is shown as 17.7 per square foot at the time of treatment and as .48 at the time of re-examination. On this basis the efficiency of treatment is calculated to be 97.3 percent. Yet in table 11 the brood in five untreated logs is given as 48.6 per square foot at the time of treatment and as 17.5 when the logs were re-examined--a normal reduction of 64.0 percent. If we assume for the sake of argument that 64 percent is a fair measure of normal mortality for the period studied, then we have a basis for correcting the estimated effectiveness in table 3. From the original brood of 17.7 per square foot we would expect to obtain 6.4 at the time of re-examination; however, we find only .48, a reduction of 92.5 percent attributable to the chemical treatment. In some of the other tables the differences are much greater. Calculations using the figures in table 7 give a 24 percent effectiveness rather than the 72.6 percent now shown.

cc: Dr. Craighead

RLFurniss:RWO

BUREAU OF
Entomology and Plant Quarantine
RECEIVED
JUN 26 1941
FOREST INSECT LABORATORY,
PORTLAND, OREGON

File No. ....
Noted by ....
FPK
RLF.

Forest Insect Laboratory
Coeur d'Alene, Idaho
June 25, 1941

Dr. F. C. Craighead

Washington, D. C.

Dear Dr. Craighead:

I am enclosing two copies of Mr. Gibson's report "Experiments with Penetrating Sprays Conducted in Lodgepole and Whitebark Pine in 1940". I should appreciate your comments and suggestions at your convenience.

The outstanding features of this report are the results obtained by dichlorethyl ether (1 part) and Diesel oil (8 parts), which may prove to be a more economical formula than the one now being used in connection with control; that is, of course, if we are able to obtain continued success with it. We are also gratified at the results obtained in whitebark pine in connection with the treating of new attacks, with the broods in the young larval stage and under fairly green, nonporous bark.

Respectfully yours,

JAMES C. EVENDEN
Senior Entomologist

Enclosures

cc to Miller, Keen, Collins

EXPERIMENTS WITH PENETRATING SPRAYS
CONDUCTED IN LODGEPOLE AND
WHITEBARK PINE IN 1940

INTRODUCTION

Tests with penetrating sprays in 1940 against the mountain pine beetle have been divided in this report into three general groups:

(1) Tests of noncommercial formulae in lodgepole pine.

(2) Tests of noncommercial formulae in whitebark pine.

(3) Tests of Dow Chemical Company formulae as authorized by the Forest Insect Division.

The tests of the sprays from the Dow Chemical Company were made in both lodgepole and whitebark pine, a preliminary report of which has already been submitted. In this report the data and discussion are more detailed, permitting those who may be interested to make a more thorough study of method and results.

Tests of both non commercial and Dow chemicals were conducted at Grand Teton Park in lodgepole pine and on the slopes of Mt. Washburn in Yellowstone Park in whitebark pine.

MATERIALS AND METHODS

Material used consisted of infested logs from trees and of standing trees. Following the examination of a six-inch strip or a standard-sized sample at the end of each log section, to determine the amount of brood, the remainder of the log was sprayed with the formula to be tested. Where trees were used to supplement data from sections, one-half of their circumference was sprayed to about five feet. Brood counts on the unsprayed side were deferred until similar counts were made on the sprayed area, thus permitting a direct measure of the

effectiveness of the control. Spray effectiveness was tested against various stages of development, where time and material permitted. This was done not only for the purpose of determining the resistance of the insect in these various stages but also to measure lethal effect under the varying bark conditions. It has been recognized that control of brood under green or wet bark is a much more difficult problem than under dry or nearly dry bark. Temperature and exposure to sunlight also vary in amount, and influence at least the speed and possibly the ultimate effectiveness of the sprays. In these experiments, the sprayed log sections were shaded to prevent exposure to sunlight. None of the sprayed areas of trees were shaded. We feel justified in believing that, with the elimination of the factor of sunlight, the data presented from the log sections are a conservative estimate of the effectiveness of the formulae.

TESTS OF NONCOMMERCIAL FORMULAE IN LODGEPOLE PINE

In July of 1940, testing of the control properties of various penetrating sprays, which has been in progress for a number of years at Grand Teton Park, was continued. The material on which the tests were made consisted of 30-inch sections of infested logs. Except that they were shaded to prevent possible sun-killing of brood, the log sections were arranged so as to closely duplicate the environment of nearby infested trees.

The success obtained in previous tests by the use of Diesel oil and a saturated solution of naphthalene in orthodichlorobenzene prompted their continuance with smaller amounts of the latter in Diesel

oil. In addition other chemicals were tested in the search for still cheaper and more effective sprays.

EXPERIMENTS

<u>Formula 1</u>

Saturated solution of naphthalene flakes in orthodichlorobenzene at 50° F. (3 lb. per gallon)....1 part

Diesel oil ....6 parts

The sections sprayed with Formula 1 yielded as good results as have been secured with the 4 parts Diesel oil to 1 part of the saturated solution. The data are shown in table 1.

Table 1 - Mountain pine beetle infested lodgepole pine treated with formula 1 (1) - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating (2)							Surviving brood one month after treating (3)						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
14.2	5	4	137	--	146	3.7	39.5	--	--	--	1	1	3.7	.27
14.5	--	2	35	--	37	3.8	9.7	--	--	--	--	--	3.8	--
12.2	7	5	51	--	63	3.2	19.7	--	--	--	--	--	3.2	--
12.1	--	--	63	--	63	3.1	20.3	--	--	--	--	--	3.1	--
14.4	1	2	28	--	31	3.7	8.4	--	--	--	2	2	3.7	.54
13.5	13	13	314	--	340	17.5	19.4	--	--	--	3	3	17.5	.17

Percent reduction in brood 99.

Brood in five check logs (4)

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

Percent reduction in brood in the above check logs 64

(1) Saturated solution of naphthalene in orthodichlorobenzene at 50° F. (3 lbs. per gallon) .... 1 part
Diesel oil .... 6 parts

(2) July 4, 1940

(3) August 5, 1940

(4) Individual log data in table 11

In spite of the wide variation in the number of brood per square foot of surface, we find there are ample data on which to base a definite conclusion as to the effectiveness of the spray used. The five logs constituted five samples containing a total of 340 insects under the 17.5 square feet of bark examined. The average was 19.4 insects per square foot. When an equal treated area was examined one month later it showed only three surviving insects.

The excellent control secured with the lower concentration of the lethal material permits reducing the cost of the spray from about 22.5¢ per gallon at present costs to about 19¢, without sacrificing any effectiveness. Prices upon which the above estimates were based are Diesel oil 10¢ per gallon, orthodichlorobenzene 70¢ per gallon, and naphthalene flakes 7¢ per pound.

<u>Formula 2</u>

Saturated solution of naphthalene in ortho-dichlorobenzene at 60° F. (3 lb. per gallon) ..... 1 part

Diesel oil .... 9 parts

A further reduction to 9 parts of oil to 1 part of the solution gave somewhat variable results, reductions in living brood per unit of area ranging from 79 to 100 percent. Eliminating the data of the third log section, which are statistically beyond the acceptable limits of variation, decreases the reduction obtained from 92 to 86 percent. The latter percent almost certainly indicates that a definite difference exists in the effectiveness of Formulae 1 and 2 as presented in tables 1 and 2. However, it is believed that if these sections could have been treated earlier in the season, thus permitting a longer exposure to the effects of the chemical, a much higher mortality would have resultd. The data for sections treated with Formula 2 are shown in table 2.

Table 2 - Mountain pine beetle infested lodgepole pine treated with formula 2 (1) - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating (2)							Surviving brood one month after treating (3)						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per. sq. ft.
10.9	--	--	35	--	35	1.3	26.9	--	--	1	13	14	2.9	4.8
12.2	4	3	23	--	30	3.2	9.4	--	--	--	--	--	3.2	--
11.0	8	9	206	--	223	2.6	85.8	--	--	1	3	4	2.8	1.4
13.7	1	1	23	--	25	3.6	6.9	--	--	--	--	--	3.6	--
14.7	--	2	31	--	33	3.8	8.7	--	--	--	7	7	3.8	1.8
13.8	3	2	61	--	66	3.6	18.3	--	--	--	12	12	3.6	3.3
11.8	4	1	25	--	30	3.1	9.7	--	--	--	--	--	3.1	--
Totals and averages	20	18	404		442	21.2	20.9	--	--	2	35	37	23.0	1.6
Without 3rd section	12	9	198	--	219	18.6	11.8	--	--	1	32	33	20.2	1.6

Percent reduction in brood 92 - (exclusive of 3rd section) - 86

Brood in 5 check logs (4)

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Saturated solution of naphthalene in orthodichlorobenzene at 50° F. (3 lb. per gallon) ..... 1 part
Diesel oil .... 9 parts

(2) July 4, 1940

(3) August 5, 1940

(4) Individual log data in table 11

If a longer exposure to Formula 2 should not give satisfactory control, the excellent results obtained with Formula 1 and less effective control with Formula 2 indicate the possibilities of acceptable results being secured with concentrations between the two. Tests with 7 and 8 parts of oil are suggested as well as a repetition of 6 and 9 to test consistency of results.

Formula 3

Saturated solution of naphthalene in orthodichlorobenzene at 50° F. (3 lb. per gallon) .... 1 part

Diesel oil .... 9 parts

Santomerse D (by weight) .... 1 percent

A third formula, differing only from the second in the addition of one percent by weight of Santomerse D, a wetting agent, gave almost as effective control as Formula 1. In addition control was consistently good, being in no case less than 94 percent for any section treated. The results indicate the wetting agent had increased the effectiveness of the spray, thus permitting a reduction in the amount of lethal material. However, because of inconsistent results in previous tests with wetting agents it is felt that further experimenting with this formula should be done before recommending it. The data are presented in table 3.

Table 3 - Mountain pine beetle infested lodgepole pine treated with formula 3 (1) - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Surviving brood one month after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
12.0	4	2	44	--	50	3.1	16.1	--	--	--	--	--	3.1	--
12.1	3	4	51	--	58	3.2	18.1	--	--	--	3	3	3.2	.94
10.4	3	7	77	--	87	1.4	62.1	--	--	--	--	--	2.7	--
13.6	1	--	44	--	45	3.6	12.5	--	--	--	2	2	3.6	.56
17.3	36	3	14	--	53	4.5	11.8	--	--	--	2	2	4.5	.44
13.6	1	1	49	--	51	3.6	14.2	--	--	--	3	3	3.6	.83
	48	17	279		344	19.4	17.7	--	--	--	10	10	20.7	.48

Percent reduction in brood 97.3 95%+

Percent reduction in brood without log 3 96.1

Brood in 5 check logs (2)

At time treated sections were sprayed							At time treated sections were examined						
64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Saturated solution of naphthalene in orthodichlorobenzene at 50° F. (3 lb. per gallon) ..... 1 part
Diesel oil .... 9 parts
Santomerse D (1% by weight)

(2) Individual log data in table 11

64%
Normal mortality

Tests of pentachlorphenol in which 2 percent by weight of that chemical was dissolved in 98 percent Diesel oil and then sprayed on mountain-pine-beetle-infested lodgepole pine logs gave no apparent control. Examinations of brood before and seven weeks after spraying revealed only a 57 percent reduction in brood and a survival averaging at least 15 insects per square foot. The data from the four sections examined are given in table 4.

Table 4 - Mountain pine beetle infested lodgepole pine treated with formula N-1[1] - Grand Teton Park - 1940

Living brood in trees attacked in 1939

	Estimated brood at time of treating							Surviving brood one month after treating						
Diameter of logs	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
14.3	5	1	27	--	33	3.7	8.9	--	--	1	10	11	3.7	3.0
14.2	33	21	49	--	103	3.7	27.9	--	--	--	30	30	3.7	8.1
13.1	12	2	192	--	206	3.4	60.6	--	--	9	92	101	3.4	29.7
12.6	4	--	148	--	152	3.3	46.1	--	--	5	66	71	3.3	21.5
	54	24	416	--	494	14.1	35.1	--	--	15	198	213	14.1	15.1

Percent reduction in brood 57

Brood in 5 check logs[2]

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6		3	11	293	307	17.5	17.5

(1) Diesel oil ....98% (by weight)
Pentachlorphenol .... 2% " "

(2) Individual log data in table 11.

Formula N-2

Pentachlorphenol (by weight) .... 3 percent
Diesel oil (by weight) .... 97 percent

An increase of the pentachlorphenol to 3 percent by weight combined with 97 percent Diesel oil, when sprayed on the infested sections, gave an indicated decrease in breed of only 26 percent, which is less than the normal mortality noted in the check sections. However, the data include one section which shows a decidedly abnormal departure from the other data, so much so that its elimination is statistically justified. Without that section the reduction is 57.5 percent, practically the same as for Formula N-1 and still ~~equally~~ unsatisfactory. The data are presented in table 5.

Table 5 - Mountain pine beetle infested lodgepole pine treated with formula N-2 (1) - Grand Teton Park - 1940

Living brood in trees attacked in 1939

	Estimated brood at time of treating							Surviving brood one month after treating						
Diameter of logs	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
11.7	--	--	12	--	12	1.5	8.0	--	--	--	13	13	3.1	4.2
14.0	4	3	82	--	89	2.9	30.7	--	--	--	215	215	2.9	74.1
13.9	--	1	53	--	54	1.8	30.0	--	--	2	32	34	3.6	9.4
12.7	5	--	164	--	169	3.3	51.2	--	--	2	59	61	3.3	18.5
11.6	3	3	95	--	101	3.0	33.7	--	--	--	76	76	3.0	25.3
10.7	8	--	27	--	35	2.8	12.5	--	--	--	17	17	2.8	6.1
	20	7	433	--	460	15.3	30.1	--	--	4	412	416	18.7	22.2

Without second section .... 29.9 .... 12.7
Percent reduction in brood 26
" " " " without second section 57.5

Brood in 5 check logs (2)

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Diesel oil ....97% (by weight)
Pentachlorphenol........ 3% " "
(2) Individual log data in table 11.

Formula N-3

Pentachlorphenol (by weight) .... 4 percent
Diesel oil (by weight) .... 96 percent

A still further increase in the pentachlorphenol to 4 percent gave indications of some control effectiveness. The average reduction in brood, however, was only 75.5 percent and the survival per square foot too high. The data are presented in table 6.

Table 6 - Mountain pine beetle infested lodgepole pine treated with formula N-3 (1) - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Surviving brood one month after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
13.2	3	2	61	--	66	3.5	18.9	--	--	--	24	24	3.5	6.9
12.6	20	8	371	--	399	3.3	120.9	--	--	--	90	90	3.3	27.3
11.5	3	--	19	--	22	1.5	14.7	--	--	--	27	27	3.0	9.0
13.3	1	--	32	--	33	1.7	19.4	--	--	--	10	10	3.5	2.9
Totals and averages	27	10	483	--	520	10.0	52.0	--	--	--	151	151	13.3	11.4

Percent reduction in brood 78

Brood in 5 check logs (2)

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Diesel oil .... 96% (by weight)
Pentachlorphenol .... 4% " "

(2) Individual log data in table 11.

Formula N-4

Pentachlorphenol (by weight) .... 6 percent

Diesel oil (by weight) .... 94 percent

The highest concentration of pentachlorphenol in the oil carrier, 6 percent by weight to 94 percent by weight of the Diesel oil, failed to produce satisfactory control. It seems apparent that this chemical in the above mixture is not effective against the mountain pine beetle in lodgepole, judging from the results secured in 1940. Table 7 contains the data concerning this formula.

Table 7 - Mountain pine beetle infested lodgepole pine treated with formula N-4 [1] - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Surviving brood one month after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
13.4	3	--	43	--	46	3.5	13.1	--	--	1	12	13	3.5	3.7
12.2	9	1	167	--	177	3.2	55.3	--	--	--	83	83	3.2	25.9
12.3	1	--	18	--	19	3.2	5.9	--	--	--	--	--	3.2	--
11.7	2	1	14	--	17	1.5	11.3	--	--	--	3	3	3.1	.9
13.7	64	33	174	--	271	3.6	75.3	--	--	--	78	78	3.6	21.7
12.7	1	4	51	--	56	3.3	17.0	--	--	--	10	10	3.3	3.0
14.3	6	2	63	--	71	3.7	19.2	--	--	--	27	27	6.2	4.3
	86	41	530	--	657	22.0	29.9	--	--	1	213	214	26.1	8.2
								Percent reduction in brood						72.6
Brood in 5 check logs [2]														
	At time treated sections were sprayed							At time treated sections were examined						
	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Diesel oil .... 94% (by weight)
Pentachlorphenol ..... 6% " "

(2) Individual log data in table 11.

Formula J-1

Dichlorethyl ether .... 1 part
Diesel oil .... 8 parts

In 1939 tests with four parts of Diesel oil to one of dichlorethyl ether gave excellent results. In 1940, although the formula was reduced to 8 parts of Diesel oil to 1 of dichlorethyl ether, the results obtained were still excellent, which indicates that it may be possible to even further reduce the amount of the dichlorethyl ether and secure satisfactory control. The data secured in the experiment conducted in 1940 are presented in table 8.

Table 8 - Mountain pine beetle infested lodgepole pine treated with formula J-1 [1] - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Surviving brood one month after treating						
	Lar.	Pup.	N.A.	NAHH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAHH	Total	Sq. ft. of area examined	No. per sq. ft.
12.8	19	5	63	--	87	3.4	25.6	--	--	--	--	--	3.4	--
12.3	--	2	76	--	78	3.2	24.4	--	--	--	--	--	3.2	--
12.0	2	3	60	--	65	3.1	21.0	--	--	--	--	--	3.1	--
11.9	2	1	29	--	32	3.1	9.7	--	--	--	--	--	3.1	--
9.8	15	16	119	--	150	2.6	57.7	--	--	--	1	1	2.6	.38
9.4	5	4	188	--	197	2.5	78.8	--	--	--	--	--	2.5	--
9.1	4	6	187	--	197	2.4	82.1	--	--	--	2	2	2.4	.83
	47	37	722	--	806	20.3	39.7				3	3	20.3	.15

Percent reduction in brood 99.6

Brood in 5 check logs [2]

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Dichlorethyl ether .... 1 part (by volume)
Diesel oil .... 8 parts " "

(2) Individual log data in table 11.

Further tests should be made with decreased concentrations of the more lethal ingredient, dichlorethyl ether.

Formula H-1

Orthonitrodiphenol .... 1 part
Diesel oil .... 3 parts

A spray comprising 1 part of orthonitrodiphenol to 3 parts of Diesel oil gave very good results. A light survival occurred and a small amount of living brood was still present in one log section at the time of examination, but their unhealthy appearance indicated their probable death. As these unhealthy survivors made up about 40 percent of the total survival, their death would lower the survival to a very small figure. It is also believed still further mortality might have occurred if the treating could have been done about June 15. For the above reasons this formula should be given further tests at the same and lower concentrations of the orthonitrodiphenol. The data secured are presented in table 9.

Table 9 - Mountain pine beetle infested lodgepole pine treated with formula R-1 [1] - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Surviving brood one month after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
8.9	2	5	178	--	185	2.3	80.5	--	--	--	7	7	2.3	3.0
8.9	--	2	94	--	96	2.3	41.7	--	--	--	--	--	2.3	--
14.3	50	11	55	--	116	3.7	31.4	3	3	4	2	12	3.7	3.2
13.6	7	5	69	--	81	3.6	22.5	--	--	--	2	2	3.6	.6
13.4	3	4	63	--	70	3.5	20.0	--	--	--	--	--	3.5	--
13.1	7	4	45	--	56	3.4	16.5	--	--	--	3	3	3.4	.9
	69	31	504	--	604	18.8	32.1	3	3	4	14	24	18.8	1.3

Percent reduction in brood 96

Brood in 5 check logs [2]

	At time treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Orthonitrodiphenol .... 1 part (by weight)
Diesel oil .... 3 parts " "
(2) Individual log data in table 11.

Formula X-1

Saturated solution of naphthalene in xylene
(3 lb. per gallon) .... 1 part

Diesel oil .... 3 parts

Tests with the above mixture were not made until July 20, by which time emergence of new adults had begun. Counts were made of emergence holes immediately before treating but, as the bark could not be removed without destroying the experiment, no differentiation between parent- and new-adult emergence holes could be made. When extensive examinations were made on August 11 it was found that emergence holes averaged 1.7 per square foot. The areas intensively examined on July 20 showed an average of about one new-adult emergence hole per square foot. If the difference in the data may be considered as indicative, new-adult emergence after treating averaged only .7 insect per square foot, which would be excellent control.

Table 10 - Mountain pine beetle infested lodgepole pine treated with formula X-1 [1] - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Surviving brood one month after treating						
	Per.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
13.2	--	1	44	--	45	3.5	12.9	--	--	--	?	?	3.5	
15.3	27	4	79	10	120	4.0	30.0	--	--	--	?	?	4.0	
14.2	--	--	57	6	63	3.7	17.0	--	--	--	9	9	3.7	2.4
13.7	--	--	51	7	58	3.6	16.1	--	--	--	--	--	3.6	
13.8	3	5	39	--	47	3.6	13.1	--	--	--	20	20	3.6	5.6
13.1	1	--	31	2	34	3.4	10.0	--	--	--	--	--	3.4	
12.7	--	--	16	--	16	3.3	4.8	--	--	--	1	1	3.3	.3
	31	10	317	25	383	25.1	15.3	--	--	--	30	30	25.1	1.7 (2)

Percent reduction in brood (less an average of 1.0 insect per square foot from both examination averages) = 95

Brood in 5 check logs (3)

	At time other treated sections were sprayed							At time treated sections were examined						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

(1) Saturated solution of naphthalene in xylene (3 lb. per gallon) .... 1 part
Diesel oil .... 5 parts

(2) Includes only last five sections

(3) Individual log data in table 11

Check Sections

A study of five sections of trees examined at the time the treated sections were sprayed, and again at the same time that the treated sections were examined, revealed a 64 percent decrease in brood. This may be considered the normal reduction in brood over that period of time. Considerable variability in brood numbers is indicated in the data from the check trees which are given in table 11.

Table 11 - Mountain pine beetle infested lodgepole pine check trees Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Brood at time treated sections were sprayed							Brood at time other sections were examined						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
12.7	48	3	232	--	283	3.3	85.8	--	3	10	129	142	5.0	28.4
12.3	3	4	184	--	191	3.2	59.7	--	--	1	40	41	3.2	12.8
12.5	3	--	139	--	142	3.3	43.0	--	--	--	39	39	3.3	11.8
12.0	10	--	60	--	70	3.1	22.6	--	--	--	68	68	3.1	21.9
10.9	--	--	9	--	9	1.4	6.4	--	--	--	17	17	2.9	5.9
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

Percent reduction in brood 64.0

CONCLUSIONS

An analysis of tests conducted with penetrating sprays on mountain-pine-beetle-infested lodgepole pine indicated a number of formulae not only gave satisfactory control but are cheaper than those now in use.

Formula 1 is apparently equally effective and three cents cheaper than the one used at Grand Teton Park in 1940. In addition it seems even more concentrated than is necessary to give effective control, and further reductions in the more expensive ingredients may be possible. However, additional tests are needed to determine if the formula will give equally effective results under more adverse circumstances and the rigorous conditions of a control project.

A saturated solution of naphthalene in xylene mixed with Diesel oil gave sufficiently promising results to warrant further tests. It is possible that xylene may be obtained at a lower cost than orthodichlorobenzene, in which case it might be substituted for the latter as a solvent for naphthalene.

The use of a wetting agent to increase the effectiveness of a low-concentration spray seems to have been successful with Formula 3. However, less wetting agent may prove just as effective, as only part of it was dissolved in the oil in this experiment. If small quantities of wetting agents make it possible to use lower concentrations of the lethal agent, still further reductions in cost may be obtained. Further experiments both with and without wetting agents are suggested.

Insufficient mortality resulted from the tests with pentachlorphenol to warrant further consideration of that chemical.

Further tests with dichlorethyl ether in Diesel oil are suggested because of the excellent results obtained in both the 1939 and 1940 tests. The lowest effective concentrations of dichlorethyl ether in oil do not seem to have been reached and further experiments with weaker mixtures are suggested. If wholesale prices reveal a comparatively low cost for this formula, it may be found as economical as those now in use.

Orthonitrodiphenol also offers a possibility as a lethal control medium in mixture with the Diesel oil. Results were quite satisfactory in the tests made and should be duplicated.

In general the tests conducted in 1940 yielded information concerning certain formulae which seem to equal in effectiveness and may prove more economical than those now accepted for general control.

TESTS OF NONCOMMERCIAL FORMULAE IN WHITEBARK PINE

Experimental treatment of mountain-pine-beetle-infested whitebark pine with noncommercial formulae was conducted at Dunraven Pass near Mt. Washburn in Yellowstone Park. Trees treated were at an elevation of about 9000 feet, on north and west exposures with slopes ranging from 20 to 45 degrees. Stand composition was chiefly whitebark pine in which there were from 10 to 25 percent lodgepole pine, Engelmann spruce, and alpine fir. Most of the treated trees were on well-shaded sites in the midst of a moderately dense stand. Ten log sections and four trees infested with the mountain pine beetle were treated with a mixture of 3 parts Diesel oil to 1 part by volume of a saturated solution of naphthalene flakes in orthodichlorobenzene. Brood subjected to the effect of the sprays included both early and advanced stages of development, the former in trees attacked in 1940 and the latter in those attacked in 1940. Before the 30-inch log sections and the trees were sprayed, counts were made of brood in order to reject material with insufficient infestation.

Spray was applied to the sections or to one side of the trees until the bark glistened with the liquid and drip started. Sprayed sections were placed on platforms off the ground and shaded with branches to prevent sun-killing of the brood. After being sprayed on July 24 the treated material was left until September 13, when examinations were made. Table 1 shows a summary of the data secured.

Table 1, part A - Mountain pine beetle infested whitebark pine treated with formula I [1] - Mt. Washburn - 1940

Living brood in trees attacked in 1939

Diameter of Logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Surviving brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft. (2)
15.7	--	2	6	10	18	4.0	4.5	--	--	--	2	2	6.2	.3
12.0	2	2	54	5	63	3.2	19.7	--	--	--	9	9	4.7	1.9
11.8	3	5	35	13	56	3.4	16.5	--	--	--	7	7	4.7	1.5
12.7	--	1	15	--	16	3.4	4.7	--	--	--	6	6	5.1	1.2
11.0	16	20	7	--	43	2.8	18.6	--	--	--	8	8	4.3	1.9
11.0	11	20	15	--	46	2.8	16.4	--	--	--	5	5	4.3	1.2
Totals and averages	32	50	132	28	242	19.6	12.3				37	37	29.3	1.3
Tree														
22.0	1	1	6	--	8	.5	16.0	--	--	--	--	--	.5	--
Grand totals and averages	33	51	138	28	250	20.1	12.44	--	--	--	37	37	29.8	1.24
Averages with reductions due to emergence from 4 sections prior to treating							11.04							.44

Percent of reduction attained as indicated by above averages = 96

(1) Diesel oil .... 3 parts (by volume)
Saturated solution of [illegible] in ortho-dichlorobenzene at 50° F. (5 lb. per gallon) ... 1 part

(2) Includes emergence which had occurred prior to treatment

As some emergence had occurred prior to treating in the two trees from which the first four sections were taken, a figure representing the amount of this pre-treatment emergence per unit of area was deducted from the final emergence figure noted seven weeks after treating. Although such procedure is subject to some error, it seemed the best solution to the problem of securing a better measure of the effectiveness of the spray. Following this deduction the average emergence for the six sections and one tree was only .44 per square foot and the decrease in living brood about 96 percent. The above figures indicate excellent control by this formula against mountain pine beetle brood in advanced stages of development. Even without the above allowances for pre-treatment emergence the indicated control may be considered satisfactory.

Control of brood in the earlier stages of development was even better than with the later stages when amount of reduction is considered. On the basis of survival per unit of area it is not so good, but it must be pointed out that surviving insects were still immature and consequently would be exposed to the spray for a much longer time than those more nearly mature. Under such conditions further reduction of surviving brood could be expected, so the ultimate mortality figure will probably compare favorably with that obtained against brood in advanced stages of development.

Data from check trees and logs at the end of part B of table 1 give some idea of the brood present in unsprayed sections and logs at the time the sprayed material was examined.

Table 1, part B

Living brood in trees attacked in 1940

Diameter of Logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Surviving brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
10.6	233	--	--	--	233	1.0	233	3	--	--	--	3	1.4	2.1
9.4	215	--	--	--	215	.5	430	5	--	--	--	5	1.2	4.2
14.5	251	--	--	--	251	.5	502	3	--	--	--	3	1.9	1.6
8.4	232	--	--	--	232	.5	464	--	--	--	--	--	1.1	--
Totals and averages	931	--	--	--	931	2.5	372.8	11	--	--	--	11	5.6	2.0
Trees														
12	Eggs and small larvae when treated							--	--	--	--	--	.5	--
19	"	"	"	"	"	"		--	--	--	--	--	.5	--
13	"	"	"	"	"	"		--	--	--	--	--	.5	--

Average survival from sections and trees . . . . : 1.6

Percent reduction as indicated from sections 99.5
" " " " " trees 100.0

CHECK SECTIONS AND TREES - LIVING BROOD

	7-23 to 29-1940							9-13 to 19-1940						
[illegible]	Eggs and small larvae							495	7	1	--	503	1.6	314.4
8.4	"	"	"	"				[illegible]	[illegible]	--	--	305	1.2	254.2
12.0	"	"	"	"				[illegible]	[illegible]	[illegible]	--	137	.5	274.0
19.0	"	"	"	"				[illegible]	[illegible]	--	--	15	.5	30.0
[illegible]	"	"	"	"				[illegible]	[illegible]	42	--	61	.5	122.0
13.0	"	"	"	"				4	--	3	--	7	.5	14.0
Totals and averages								[illegible]	[illegible]	52	--	1,028	4.5	[illegible]

In a second experiment involving eight sections and five trees, results obtained were not significantly different. The data are presented in table 2 and again we find the trees and sections from trees containing advanced stages of development showing an indicated smaller decrease in brood than similar material containing brood in earlier stages of development. However, the differences are too small to be considered significant, all material having shown satisfactory reduction of brood. In spite of a reduction in the lethal dosage in Formula II, the results showed no significant difference to that of Formula I, which would seem to indicate that the dosage of lethal material is higher than necessary. If such is the case, Formula II, which is the cheaper, could be used with no sacrifice in effectiveness. The same procedure as in table 1, in reducing the final emergence figure, has been made of data from the first three sections and one tree, in which emergence had occurred before treating.

Table 2, part A - Mountain pine beetle infested whitebark pine treated with formula II (1) - Mt. Washburn - 1940

Living brood in trees attacked in 1939

Diameter of Logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Surviving brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No per sq. ft.
14.3	4	1	16	9	30	3.7	8.1	--	--	--	--	--	1.9	--
12.7	2	1	68	5	76	3.3	23.0	--	--	--	14	14	5.0	2.8
11.0	--	1	24	1	26	1.4	18.6	--	--	--	9	9	4.3	2.1
11.0	16	20	7	--	43	2.8	15.4	--	--	--	8	8	4.3	1.9
Totals and averages	22	23	115	15	175	11.2	15.6	--	--	--	31	31	15.5	2.0
Trees														
31.0	96	4	9	--	109	1.0	109	--	--	--	--	--	.5	--
18.0			1	2	3	.5	6	--	--	--	--	--	.5	--
11.0	--	1	8	--	9	1.0	9	--	--	--	--	--	.5	--
Totals and averages	96	5	18	2	121	2.5	48.4	--	--	--	--	--	1.5	--
Grand totals and averages	118	28	133	17	296	13.7	21.6	--	--	--	31	31	17.0	1.8

Averages with reduction due to emergence from 3 sections and 1 tree, prior to treating: 19.58 ... .53 per sq.ft.

Percent of reduction obtained as indicated by above averages : 97.0

(1) Diesel oil .... 4 parts
Saturated solution of orthodichlorobenzene in orthodichlorobenzene at 70° F. (3 lb. per gallon) ... 1 part

Table 2, part B

Living brood in trees attacked in 1940

Diameter of Logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No per sq. ft.	Surviving brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
10.5	276	--	--	--	276	1.0	276	--	--	--	--	--	1.4	--
12.0	251	--	--	--	251	.5	502	--	--	--	--	--	1.6	--
15.0	201	--	--	--	201	1.0	201	8	--	--	--	8	2.0	4.0
9.6	287	--	--	--	287	.5	574	1	--	--	--	1	1.3	.8
Totals and averages	1,015	--	--	--	1,015	3.0	338.3	9	--	--	--	9	6.3	1.43
Trees														
18.0	Eggs and small larvae					.5	?	1	--	--	--	1	1.0	1.0
11.0	"	"	"	"		.5	?	2	--	--	--	2	1.0	2.0
Totals and Averages	"	"	"	"		1.0	?	3	--	--	--	3	2.0	1.5
Grand totals and averages	1,015	--	--	--	1,015	4.0	338.3	12	--	--	--	12	8.3	1.45

Percent of reduction obtained as indicated by above averages 99.5

CONCLUSIONS

The outstanding result of these two experiments in whitebark pine is the excellent control secured, which shows that the use of penetrating sprays is feasible in whitebark pine against the mountain pine beetle in both advanced and early stages of brood development. The excellent results obtained seem to warrant a test of the method on a large scale.

TESTS TO DETERMINE REPELLENT AND CONTROL EFFECTIVNESS OF COMMERCIAL FORMULAE MANUFACTURED BY THE DOW CHEMICAL COMPANY 1940

INTRODUCTION

In the spring of 1940 three formulae manufactured by the Dow Chemical Company were sent by authorization of the Washington office of the Bureau of Entomology and Plant Quarantine to the Coeur d'Alene Forest Insect Laboratory to be tested for their effectiveness in repelling and controlling the mountain pine beetle. These formulae were (1) para-chloro-phenoxy-ethoxy-ethyl chloride (K-655), (2) para-tertiary-butyl-phenoxy ethanol (K-58), and (3) dichlordiphenyloxides (2-X), which will be referred to in the rest of this report as K-655, K-58 and 2-X.

MATERIALS AND METHODS

In all tests of these formulae 1 part by volume of each of the above chemicals was mixed with 3 parts kerosene. Materials treated consisted of 30-inch log sections of lodgepole and whitebark pine supplemented by standing infested trees, all infested with the mountain pine beetle.

Log sections and trees were sprayed until the bark surface glistened with the unabsorbed oil and dripping was ready to start, thus assuring thorough saturation. Unsprayed sections were placed among those treated to serve as checks. Both treated and untreated sections were set on end on low, open-floored platforms in the shade of timber and branches to prevent any possibility of sun-killing but otherwise to closely duplicate natural conditions of exposure.

One-half the circumference of the basal five feet of trees was sprayed and the other half left unsprayed to serve as a check on the treatment.

EXPERIMENTS

Tests Against Advanced Stages of Brood Development in Lodgepole Pine With Formula K-655

On June 25 and 26 three lots each of five 30-inch sections of lodgepole pine at Grand Teton Park were sprayed with the three formulae. To supplement the data from the logs, three lots of five trees each were sprayed with the same formulae on July 8. Both the trees and the log sections were examined in early August, the individual data from the sections being given in the following tables.

Table 1 - Mountain pine beetle infested lodgepole pine treated with Formula K-655 - Grand Teton Park - 1940

Living brood in trees attacked in 1939

	Estimated brood at time of treating							Estimated brood six weeks after treating						
Diameter of Logs	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
9.9	5	4	31	--	40	1.3	30.8	--	--	--	20	20	2.7	7.4
14.6	1	4	101	--	106	1.9	55.8	--	--	--	7	7	4.0	1.8
14.0	1	3	27	--	31	1.8	17.2	--	--	--	9	9	4.0	2.2
15.3	6	11	189	--	206	2.0	103.0	--	--	--	1	1	2.8	.4
15.3	2	9	41	--	52	2.0	26.0	--	--	--	12	12	2.5	4.8
13.8	15	31	389	--	435	9.0	48.3	--	--	--	49	49	16.0	3.1
Percent reduction in brood														94

Data from Untreated Sections

	On June 26							On August 3						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

Inspection of the data in the preceding table reveals considerable variation in the brood at the time of treating and in the survival after treating. Some survival occurred in all sections, being high in two and comparatively low in the other three but averaging too high per square foot to be considered as satisfactory control.

<u>With Formula 2-X</u>

Percentage of reduction was practically as great with this formula as with K-655, but the number surviving per square foot was even higher, thus placing its effectiveness in an even less favorable position than with formula K-655.

Table 2 - Mountain pine beetle infested lodgepole pine treated with Formula 2-X - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Estimated brood six weeks after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
12.5	2	3	36	--	41	1.6	25.6	--	--	--	4	4	3.0	1.3
12.8	63	21	77	--	161	1.6	97.5	--	--	1	6	7	4.0	1.8
14.5	14	8	131	--	153	1.9	80.5	4	6	2	28	40	4.1	9.8
14.0	9	30	188	--	227	1.8	126.1	--	--	4	29	33	4.0	8.2
11.1	12	1	17	--	30	1.5	20.7	--	--	1	11	12	3.2	3.8
13.0	100	63	449	--	612	8.4	72.9	4	6	8	78	96	18.3	5.2

Percent reduction in brood 93

Data from Untreated Sections

	On June 26							On August 3						
12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

With Formula K-58

Results with Formula K-58 were not satisfactory. The brood reduction noted was almost exactly the same as that in untreated trees, which would indicate the spray had no lethal effect whatever.

The data are given in table 3.

Table 3 - Mountain pine beetle infested lodgepole pine treated with Formula K-58 - Grand Teton Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NARM	Total	Sq. ft. of area examined	No. per sq. ft.	Estimated brood six weeks after treating: Lar.	Pup.	N.A.	NARM	Total	Sq. ft. of area examined	No. per sq. ft.
12.2	2	1	27	--	30	1.6	18.7	--	--	4	12	16	3.4	4.7
12.7	--	9	40	--	49	1.7	29.7	4	2	5	47	58	3.7	15.7
13.4	--	5	63	--	68	1.8	38.9	--	--	6	64	70	3.7	18.9
12.5	1	--	85	--	86	1.6	52.1	--	--	1	33	34	3.4	10.0
9.9	10	11	126	--	147	1.3	113.0	--	--	2	119	121	2.8	43.2
12.1	13	26	341	--	380	8.0	48.9	4	2	18	275	299	17.0	17.6

Percent reduction in brood 64

Data from Untreated Sections

On June 26 / On August 3

12.1	64	7	624	--	695	14.3	48.6	--	3	11	293	307	17.5	17.5

Extensive examinations were made of 14 trees treated with the same three chemicals to determine if any difference in control effectiveness might result from spraying sections of logs rather than trees. The data are given in the following summarization.

Table 4 - Data from extensive examination of mountain pine beetle infested lodgepole pine - Grand Teton Park - 1940

TREES TREATED WITH

K-655		2-X		K-58	
Tree No.	Percent reduction in brood	Tree No.	Percent reduction in brood	Tree No.	Percent reduction in brood
1	75	5	95	10	60
2	98	6	90	11	50
3	98	7	95	12	50
4	99	8	95	13	90
--	--	9	95	14	90
Average	92.5		94		68

The data presented in table 4 are from trees that were attacked in the same year as those from which the sections were taken. The variability of the results in individual trees is again brought out in the data in table 4.

The general agreement of the average reduction noted in table 4 with that from the sections that were intensively examined serves to further indicate that the latter is representative of conditions.

Repellent and Control Effect Against Young Brood in Lodgepole Pine

To test the repellent and control effect of the formulae, three lots of five sections each of lodgepole pine in the initial stages of attack by the mountain pine beetle were treated on August 1 in the same manner as the sections sprayed in June. Three unsprayed sections were placed with each sprayed lot of five logs. To supplement the above tests one-half the circumference of the base of trees in the same initial stages of attack was treated, two each with K-655 and K-58 and three with 2-X. Trees were selected that showed initial stages of attack, because presence of the latter indicated the trees were desirable host material and eliminated the problem of chance immunity if unattacked trees had been selected.

Prior to treatment, all sections and trees were carefully examined and all new attacks marked, in order that any attacks subsequent to treatment could be easily identified as such.

From a few preliminary examinations it was found that, due to the comparatively few attacks per unit of area and the high normal mortality of brood in egg and tiny-larval stages of development, a clearer idea of the control effectiveness of the sprays was obtainable by extensive examinations of large areas than by intensive brood counts on small samples, so the former method was adopted. The observations are summarized in table 5.

Table 5 - Control and repellent effect of Dow Chemicals on mountain pine and secondary bark beetles - Grand Teton Park - 1940

FORMULA K-655

Material treated	Sq.ft. of bark surface examined	Control effect on mountain pine beetle	Attacks after treating by: Mountain pine beetle	Attacks after treating by: Secondary bark beetles
Log sections	3	Complete	None	None
" "	3	None	"	"
" "	2	"	"	"
" "	4	"	"	"
" "	3	"	Few	Many
Totals	15			
Tree (1)	9	Good	2	None
"	6	Light	3	"
Totals	15			

(1) One-half of circumference of basal 5 ft. of tree treated

UNTREATED CHECK SECTIONS

Material treated	Sq.ft. of bark surface examined	Control effect on mountain pine beetle	Mountain pine beetle	Secondary bark beetles
Log sections	.5	Normal development	None	Many
" "	1.0	" "	"	"
" "	4.0	" "	Few	"
" "	1.0	" "	None	Few
" "	1.0	" "	"	Many
" "	1.5	" "	Many	"
" "	5.0	" "	"	"
" "	6.0	" "	"	Few
" "	6.0	" "	"	"
Totals	26.0			

From the preceding table it is seen that control of the mountain pine beetle by Formula K-655 is unsatisfactory. The green bark probably prevents most of the spray penetrating in sufficient quantities to have any appreciable effect on the brood. However, it does seem to be somewhat repellent to both the mountain pine and secondary bark beetles but is not sufficiently effective in that respect to be considered satisfactory. Observations from untreated check sections are summarized in the second part of the table.

Formula 2-X gave somewhat better but still insufficient control of the mountain pine beetle to be satisfactory. As a repellent it was no more effective than K-655 against the mountain pine beetle but was completely effective against secondary bark beetles. A summary of the data is presented in table 6.

Table 6 - Control and repellent effect of Dow Chemicals on mountain pine and secondary bark beetles - Grand Teton Park - 1940

FORMULA 2-X

Material treated	Sq. ft. of bark surface examined	Control effect on mountain pine beetle	Attacks after treating by Mountain pine beetle	Attacks after treating by Secondary bark beetle
Log sections	7	Light	Few	None
" "	6	"	None	"
" "	1	"	Few	"
" "	6	Very little	None	"
" "	2	" "	Few	"
Totals	22			
Tree(1)	6	Light	Few	None
"	1	"	"	"

(1) One-half of circumference of basal 5 feet of tree treated

Table 7

FORMULA K-5E

Log sections	1.5	None	None	1
" "	2.0	"	"	Light
" "	1.5	"	"	None
" "	3.0	"	"	"
" "	2.0	"	Heavy	"
Totals	10.0			
Tree(1)	10.0	None	2	Many
"	7.5	Light	30	None

(1) One-half of circumference of basal 5 feet of tree treated

Formula K-58 was the least effective in control of the mountain pine beetle of the three formulae, and gave unsatisfactory results as a repellent against both the mountain pine and secondary bark beetles.

All three formulae affect living cambium, causing spotty discoloration and an apparent drying out of the area affected.

Tests Conducted in Whitebark Pine
Mt. Washburn, Yellowstone Park - 1940

This experiment was also divided into two sections, based on brood development at the time of treatment, thus permitting a comparison of effectiveness of the spray formula on brood in both early and advanced stages of the mountain pine beetle.

Both log sections and trees were used in the experiment. The data from treatment of trees attacked in 1939 with Formula K-655 are presented in table 8.

Table 8 - Mountain pine beetle infested whitebark pine treated with Formula K-655 - Yellowstone Park - 1940

Living brood in trees attacked in 1939

Diameter of Logs	Estimated brood at time of treating							Brood eight weeks after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
13.8			13	2	15	1.8	8.3	--	--	--	5	5	5.4	.9
12.7			30	2	32	1.7	18.8	--	--	--	4	4	5.0	.8
13.3	3	1	4	--	8	1.7	4.7	--	--	--	2	2	5.2	.4
10.8	3	6	9	--	18	1.4	12.9	--	--	--	5	5	4.2	1.2
Trees														
19	--	--	1	16	17	.5	34	--	--	--	2	2	.5	4
12	--	--	2	2	4	.5	8	--	--	--	--	--	.5	--
Totals and averages	6	7	59	22	94	7.6	12.4	--	--	--	18	18	20.8	.87
Less .87 brood per sq. ft. due to emergence prior to treating							11.9							.34
Percent reduction in brood														97

From the preceding table it may be seen that the reduction obtained was excellent. An explanation of the data given is, however, necessary. Shortage of accessible material made it necessary to select some log sections from which a small percent of the brood had already emerged before it was treated. Such emergence occurred from the first two sections and the two trees. It seems justifiable then to reduce the average brood which had emerged eight weeks after treatment by an amount equal to that which had emerged before treatment from the two sections and two trees concerned. As the pre-treatment emergence was about 5.0 per square foot and that after treatment averaged about .97 per square foot, it seems justifiable to eliminate the entire emergence figure after treatment from two sections and two trees, leaving only .34 emergence per average square foot not eliminated, which was from the other two sections which had not shown emergence prior to treating. After an equal elimination of .5 insect per square foot from the pre-treatment figure, we have an average reduction in brood of about 97 per-cent. Treating the data in this manner gives slightly different totals from those shown in the first report. Against the eggs and tiny larvae in trees attacked in 1940, Formula K-655 did not seem to be so effective. This can be expected with the bark still in practically its original green state, through which it is ordinarily considered very difficult for sprays to penetrate.

The data secured are shown in table 9.

Table 9 - Mountain pine beetle infested whitebark pine treated with Formula K-655 - Yellowstone Park - 1940

Living brood in trees attacked in 1940

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Estimated brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
10.9	157	--	--	--	157	.5	314	72	--	--	--	72	1.4	51.4
10.1	198	--	--	--	198	.5	396	39	--	--	--	39	1.3	30.0
12.9	251	--	--	--	251	.5	502	165	1	--	--	166	1.7	97.7
8.8	232	--	--	--	232	.5	464	56	--	--	--	56	1.2	46.7
9.2	287	--	--	--	287	.5	574	25	1	--	--	26	1.2	21.7
Totals and averages	1,125	--	--	--	1,125	2.5	450	357	2	--	--	359	6.8	51.3
Trees	Brood on 9/16/40 in untreated portion							Brood on 9/16/40 on treated portion						
12	33	--	--	--	33	.5	66	16	--	--	--	16	.5	32

The five sections showed an average reduction in brood of about 88.5 percent between the time of treatment and seven weeks later. The two trees, on which no intensive examination was made at the time of treating, showed a difference of about 87 percent in brood on treated and untreated sides on September 16. An average of the data from sections and trees revealed an average reduction in brood on the treated side of about 87.3 percent. While such a reduction is good and might be even greater with a longer exposure to the chemical, the survival per unit of area is too high to be able to consider the effect of the formula as satisfactory.

Although the control obtained with Formula K-655 on advanced stages of development was almost complete, it was unsatisfactory against the earlier stages of mountain pine beetle brood and for that reason cannot be considered satisfactory. Normal mortality, judging from the two sections serving as checks, was about 38 percent for brood in early stages of development. Formula 2-X did not give significantly different results from Formula K-655. The data from sections in advanced stages of development are given in table 10.

Table 10 - Mountain pine beetle infested whitebark pine treated with Formula 2-X - Yellowstone Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating							Estimated brood seven weeks after treating						
	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
15.2	4	6	13	2	25	2.0	12.6	--	--	--	9	9	6.0	1.5
13.2	--	--	28	9	37	1.7	21.8	--	--	--	13	13	5.2	2.5
13.0	--	--	6	--	6	1 .7	3.5	--	--	--	19	19	5.1	3.7
10.1	3	3	5	--	11	1.3	8.3	--	--	--	5	5	4.0	1.3
Totals and averages	7	9	52	11	79	6.7	11.8	--	--	--	46	46	20.3	2.3
Trees														
15	--	--	2	7	9	.5	18	--	--	--	4	4	.5	8
11	--	--	2	1	3	.5	6	--	--	--	--	--	.5	--
Totals and averages	--	--	4	8	12	1.0	12	--	--	--	4	4	1.0	4.0
Grand totals & averages	7	9	56	19	91	7.7	11.8	--	--	--	50	50	21.3	2.35

After deductions made for early emergence 9.8 .23

Percent reduction in brood 97.5

Making similar deductions to those for table 8 we have a pre-treatment emergence of about 3.0 per square foot to be deducted from emergence noted at the time of treatment of about 2.7, thereby indicating that all the emergence noted in the first three sections and the two trees probably occurred prior to treatment. The remaining emergence would only amount to about .23 insect per square foot and indicates that the reduction in brood had been about 97.5 percent.

In table 11 the data for the effect of Formula 2-X on brood from trees attacked in 1940 are given.

Table 11 - Mountain pine beetle infested whitebark pine treated with Formula 2-X - Yellowstone Park - 1940

Living brood in trees attacked in 1940

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Estimated brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
12.2	97	--	--	--	97	.5	194	69	--	--	--	69	1.6	43.1
9.3	174	--	--	--	174	.5	348	45	--	--	--	45	1.2	36.9
12.6	251	--	--	--	251	.5	502	58	--	--	--	58	1.6	35.1
10.1	232	--	--	--	232	.5	464	34	--	--	--	34	1.3	25.8
8.6	287	--	--	--	287	.5	574	131	--	--	--	131	1.1	116.4
Totals and averages	1,041	--	--	--	1,041	2.5	416.4	337	--	--	--	337	6.8	49.6
Trees														
13	77	--	--	--	77	.5	154	25	1	--	--	26	.5	52
13	70	6	1	--	77	.5	154	44	--	--	--	44	.5	88
Totals and averages	147	6	1	--	154	1.0	154	69	1	--	--	70	1.0	70
Grand totals & averages	1,188	6	1	--	1,195	3.5	341.4	406	1	--	--	407	7.8	52.2

Percent reduction in brood 85

It is to be seen that although a decided reduction in brood resulted from treatment with this spray the survival is still too high and would probably remain so even had there been a longer exposure with considerably more mortality between treatment and examination.

The unsatisfactory results in treating brood in the early stages of development with Formula 2-X would make its general use in whitebark pine unsatisfactory.

Formula K-58 proved the least effective of the three formulae tested against the mountain pine beetle in whitebark pine. The data from tests made against late stages of development are given in table 12.

Table 12 - Mountain pine beetle infested whitebark pine treated with Formula X-58 - Yellowstone Park - 1940

Living brood in trees attacked in 1939

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Estimated brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
13.6	2	3	11	--	16	1.8	8.9	--	--	--	30	30	5.3	5.7
13.5	2	3	22	10	37	1.7	21.3	--	--	1	24	25	5.2	4.8
13.0	--	--	13	2	15	1.7	8.8	--	--	--	29	29	5.1	5.7
10.4	7	3	16	--	26	1.4	18.6	--	--	--	9	9	4.1	2.2
Totals and averages	11	9	62	12	94	6.6	14.2	--	--	1	92	93	19.7	4.7
Trees														
12	--	--	12	--	12	1.0	12	--	--	--	2	2	.5	4
12	4	2	19	--	25	1.0	25	--	--	--	2	2	.5	4
Totals and averages	4	2	31	--	37	2.0	18.5	--	--	--	4	4	1.0	4
Grand totals & averages	15	11	93	12	131	8.6	15.2	--	--	1	96	97	20.7	4.1
Averages following deductions due to pre-treating emergence							13.8							3.0
Percent reduction in brood														78.5

From the data in the preceding table it is seen that reduction in bfood by the use of spray K-58 averaged about 67 percent. One tree included in this data in the earlier report has upon further consideration been included in the data in table 13. As that tree had a very heavy brood, its removal has decidedly reduced the average brood both before and after treating.

Again we find the pre-treatment emergence in some of the sections requiring a reduction from the totals of brood before and after treatment in order to properly evaluate the effectiveness of the formula. This reduction, from the data of the first three sections, increases the indicated effectiveness of the formula to 75.5 percent, which, however, cannot be considered as satisfactory control.

Against brood in the early stages of development the formula also gave unsatisfactory control. The data are given in table 13.

Table 13 - Mountain pine beetle infested whitebark pine treated with Formula E-58 - Yellowstone Park - 1940

Living brood in trees attacked in 1940

Diameter of logs	Estimated brood at time of treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.	Estimated brood seven weeks after treating: Lar.	Pup.	N.A.	NAEH	Total	Sq. ft. of area examined	No. per sq. ft.
11.5	120	--	--	--	120	.5	240	122	--	--	--	122	1.5	81.3
9.6	144	--	--	--	144	.5	288	109	--	--	--	109	1.3	86.8
12.3	251	--	--	--	251	.5	502	170	--	--	--	170	1.6	106.2
9.4	232	--	--	--	232	.5	464	41	1	--	--	42	1.2	34.1
8.8	287	--	--	--	287	.5	574	89	--	--	--	89	1.2	77.3
Totals and averages	1,034	--	--	--	1,034	2.5	413.6	531	1	--	--	532	6.8	78.8
Trees														
11	Eggs and tiny larvae at time of treatment							18	--	--	--	18	.5	36
16	"	"	"	" "	" "	"		96	--	--	--	96	.5	192
Totals and averages								114	--	--	--	114	1.0	228
Grand totals & averages	1,034	--	--	--	1,034	2.5	413.6	645	1	--	--	646	7.8	85.9

Percent reduction in brood 79

From the data in table 13 it is seen that a very numerous brood was greatly reduced but the survival was still too high to consider the formula as giving satisfactory control.

A surprising feature of the action of this formula was that it gave no better control on advanced stages of development than on early stages. There is a slight possibility that sample variation may be responsible, but the large amount of area covered should prevent a large difference from that source.

CONCLUSIONS

Treatment with the three Dow Chemicals against mountain pine beetle brood in the advanced stages of development caused heavy mortality with K-655 and 2-X, but still left too many survivors per square foot of bark surface. Formula K-58 gave decidedly unsatisfactory results. Against brood from recent attacks in lodgepole pine, results were unsatisfactory because of erratic control as well as too much survival.

As repellents these formulae were also unsatisfactory against attacks of the mountain pine beetle. Formulae K-655 and 2-X were most repellent but insufficiently so to warrant their use for that purpose. Repellent effect was somewhat greater against secondary bark beetles, _Ips_ sp., _Pityogenes knechteli_, _Pityophthorus burkei_ and others, with formula 2-X fully repellent.

Against brood of the mountain pine beetle in whitebark pine formulas K-655 and 2-X gave excellent control, but formula K-58 did not give acceptable results. Brood in trees recently attacked by the mountain pine beetle was unsufficiently controlled by the formulae, with formula K-58 again the least effective.

In general it may be said that the formulas tested can not be recommended because the conditions under which they are effective are too limited.

SUMMARY

Three formulae of the Dow Chemical Company were tested for effectiveness of control against advanced and early stages of development of the mountain pine beetle in lodgepole and whitebark pine.

Under only one condition were two of the three (Formulae K-655 and 2-X) found to give satisfactory control and that was against brood in advanced stages of development in whitebark pine.

As repellents of the mountain pine beetle none were effective, but formula 2-X prevented attack of secondary bark beetles.

These formulae cannot be recommended for control of the mountain pine beetle because the conditions under which they are effective are too limited.

GENERAL SUMMARY

Tests of spray formulae for the control of the mountain pine beetle in lodgepole and whitebark pine reveal certain formulae to be highly effective and cheaper than those now in use. If duplicate and more rigorous tests of the more promising formulae yield equally good results they can supplant those now in use.

An important phase of experiments conducted in 1940 was the determination that penetrating sprays may be used in both lodgepole and whitebark pine. Control in the latter species proved to be less of a problem than was expected when the experiments were begun.

The three commercial formulae tested were not sufficiently effective to warrant recommending their use. Only against brood in the advanced stages of development in whitebark were two of the three formulae effective. As repellents they were ineffective against the mountain pine beetle, but one prevented attack of secondary insects.